MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 3, 2015/2016**

## EME1046 – PRINCIPLES OF THERMODYNAMICS

( ME )

01 JUNE 2016
2.30 p.m – 4.30 p.m
( 2 Hours )

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**INSTRUCTIONS TO STUDENTS**

1. This question paper consists of 5 printed pages (including the cover page) with four questions.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of marks for each question is shown.

3. Please write all your answers in the Answer Booklet provided.

4. A property tables booklet is provided.

5. All necessary workings MUST be shown.

**Question 1 (25 marks)**

a) A mass of 20 kg is contained in a closed system. It then undergoes a process in which there is a heat transfer of 1080 kJ from the system to the surroundings. The work done on the system is 300 kJ. Determine the final specific internal energy if the initial specific internal energy of the system is 360 kJ/kg. The kinetic or potential energy are negligible. [5 marks]

b) A piston-cylinder initially contains refrigerant-134a as superheated vapor at 30°C and 500kPa.
The refrigerant is then cooled at constant pressure to a saturated liquid.

i) Determine the final temperature of the saturated liquid R-134a. [1 mark]

ii) Determine the specific volume and specific internal energy for both initial and final state of the R-134a. [5 marks]

iii) Sketch the process on the $P$- $v$ and $T$- $v$ diagram with respect to the saturated liquid and saturated vapor lines. Label all the states and use arrows to indicate the direction of the process. [6 marks]

iv) Calculate the work done during this process, in kJ/kg. [4 marks]

v) Determine the heat transfer, in kJ/kg. [4 marks]

**Continued...**

**Question 2 (25 marks)**

a) 13 kg/s of saturated vapor of water at 500 kPa (stream 1) enters an adiabatic mixing chamber and mixes with another stream of water at 500 kPa and 120°C (stream2). Both streams mix in the chamber and leave as saturated liquid at 500 kPa. Assuming a steady state operation, determine the the mass flow rates of stream 2.

[10 marks]

b) Water enters a steam turbine at 10 MPa, 500°C and mass flow rate of 100 kg/s. 25 kg/s of the water leave at the middle section of the turbine at 5 MPa and 300°C. The remaining of the water leaves the turbine at 75 kPa with a quality of 90%. A heat loss of 30 kJ/s occurs during this process. If the kinetic and potential energies are negligible, determine the total power output of the turbine.

[15 marks]

**Continued...**

**Question 3 (25 marks)**

a) Write short notes on the following terms, in the context of Engineering Thermodynamics.

i) The second law of thermodynamics [2 marks]

ii) Heat pump [2 marks]

iii) Carnot heat engine [2 marks]

iv) Perpetual Motion Machine [2 marks]

b) A Carnot heat pump keeps a house at 23 $^0$C by extracting heat from outside air on a day when the air temperature outside is 3 $^0$C.
For the above mentioned temperature conditions, inventor A claims that to have developed a heat pump with a Coefficient of Performance, COP of 11.9. Another two inventors B and C say that they can do better with COP of 14.8 and 17.2 respectively. Discuss which of the heat pump is reversible, irreversible or impossible. [6 marks]

c) A heat engine operates between two reservoirs at temperature 700 $^0$C and 30 $^0$C. The heat transfer to the heat engine is 3000 kJ.

i) What is the maximum efficiency of the heat engine if it is a reversible heat engine ? [3 marks]

ii) If the heat rejected to the reservoir at 30 $^0$C is 1500 kJ, find the thermal efficiency of the heat engine. [4 marks]

iii) An inventor claims to have developed a heat engine that produces a net work output of 2200 kJ between the two reservoirs. Evaluate this claim. Assume no other energy transfer to the surrounding. [4 marks]

**Continued...**

**Question 4 (25 marks)**

a) Name the two mechanisms that entropy can be transferred to or from a system. [2 marks]

b) Express the Clausius Inequality and show that it is used to define the increase of entropy principle by the equation :

$$\Delta S_{sys} = S_2 - S_1 = \int_1^2 \frac{\delta Q}{T} + S_{gen}$$

[6 marks]

c) Air enters a compressor steadily at 200 kPa and 25 $^0$C with a low velocity and exits at 1.2MPa, 277 $^0$C with a velocity of 100 m/s. The compressor is cooled by ambient air at 15 $^0$C at a rate of 32 kJ/s. The power input to the compressor is 350 kW. Determine :

i) The mass flow rate of air and [9 marks]

ii) The rate of entropy generation. [8 marks]

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